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RESEARCH PAPER

Adaptation of Intensively Reared Pikeperch (*Sander lucioperca*) Juveniles to Pond Culture and Subsequent Re-Adaptation to a Recirculation Aquaculture System

Blecha Miroslav[1,]*, Kristan Jiri[1], Policar Tomas[1]
[1] University of South Bohemia in Ceske Budejovice, Faculty of Fisheries and Protection of Waters, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Research Institute of Fish Culture and Hydrobiology, Zátiší 728/II, 389 25 Vodňany, Czech Republic.

* Corresponding Author: Tel.: +420.728 667060; Fax: ;
E-mail: blechm00@frov.jcu.cz

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Abstract

A combination of intensive rearing and pond culture was evaluated on its benefits for pikeperch year-round production. Fifteen hundred intensively reared juveniles (group IRJ) and 1500 pond-reared juvenile pikeperch as a control (group C) were divided into three batches and stocked into three ponds for 178-day long culture. Survival of fish in group IRJ was significantly higher (65.2 ± 15.9%) compared to group C (47.3±1.6%) (P<0.05). SGR (group IRJ = 0.018±0.012%.d-1; group C = 0.014±0.027%.d-1) and Fulton coefficient (FC for group IRJ = 1.02±0.13; FC for group C = 0.95±0.57) did not differ at the end of pond culture which included winter and spring seasons. After harvesting, fish from group IRJ were transferred to a recirculation aquaculture system and after a short adaptation period, they were fed with pellet feed. The duration of following intensive rearing in the RAS lasted 46 days. SGR was 0.732±0.441%.d-1, FCR = 2.1±1.2, FC = 1.20±0.09 and survival rate was 98.4±0.9% at the end of the 46-day rearing period. No difficulties were observed in adaptation of intensively cultured juveniles to pond conditions. During the study, it was obtained a high survival rate and excellent ability of pikeperch juveniles to consume dry feed after their re-adaptation to recirculation aquaculture system.

Keywords: Intensive culture, pellet feed, pond rearing, survival.

Introduction

Pikeperch (*Sander lucioperca*) is one of the most attractive freshwater fish for European aquaculture (Blecha *et al*., 2015; Kristan *et al*., in press) and its diversification (Samarin *et al.*, 2015) due to flesh palatability and attractiveness to anglers (Schulz *et al*., 2007; Kristan *et al*., 2013). The demand for pikeperch is increasing (Wang *et al*., 2009), while the wild populations in Europe are decreasing due to overfishing (Dil, 2008; Muller-Belecke and Zienert 2008). The main role of pikeperch in open waters is to regulate the populations of small cyprinids (Peterka *et al*., 2003). In the past, pikeperch were farmed in ponds or lakes (Hilge and Steffens, 1996), but in the last few decades they have been successfully reared in combination of pond and recirculation aquaculture systems (RAS) (Zakes and Demska-Zakes, 1998; Policar *et al*., 2013). It is possible to rear the pikeperch under complete RAS conditions as well (Molnar *et al*., 2004).

The combination of pond and RAS rearing is based on 6-8 weeks of extensive pond rearing followed by harvesting and converting the pikeperch juveniles with TL 35–55 mm to an artificial diet and RAS conditions (Ruuhijarvi and Hyvarinen, 1996; Zakes and Demska-Zakes, 1996; Zakes, 1997). Mentioned culture technic is well described in Policar *et al*. (2014). According to their experience, after hormonally stimulated semi-artificial spawning, pikeperch larvae are stocked to small (maximum 1.5 ha) ponds which were wintered and fertilised before. When the pikeperch juveniles achieve the total length of 30-50 mm or rapid decrease of zooplankton abundance is observed, the ponds are drained and harvested and the juveniles are moved to RAS for the second part of the culture. To convert the juveniles from live to pellet feed a technic called co-feeding (mixture of live and pellet feed) is applied. During 10-12 days, the live feed (frozen bloodworm) is mixed with pellet feed. The rate of live feed is being decreased in time and in contrary, rate of pellet feed goes up for 25% every two days until the fish intake the pellet feed only. This rearing method provides a stable production of high-quality pikeperch juveniles for subsequent aquaculture in countries with large pond area such as Czech Republic, Hungary, Germany, etc. (Policar *et al*., 2014).

The primary objective of our study was to assess the capacity of intensively cultured pikeperch juveniles to adapt to pond culture and then to re-adapt to RAS conditions. This approach was tested as an alternative method which can provide year-round pikeperch production.

Materials and Methods

Fish Groups and Characteristics of Pond Culture

Intensively reared juveniles used in this study were obtained from Experimental Fish Facility of the Faculty of Fisheries and Protection of Waters (FFPW). Before this study, they were reared in RAS (for 120 days) with water temperature (WT) = 23.6 ± 1.3°C, oxygen saturation (OS) = 104 ± 8 %, light regime 12 hours light and 12 hours dark, and fed with pelleted feed (BioMar, INICIO Plus 2 mm) during the entire light period of the day. To acclimate the fish for pond rearing, WT in rearing tanks was decreased (about 1°C per day) to pond WT (8.2 °C), fourteen days before stocking. Pond reared fish (stocked into ponds in May after semiartificial spawning) were captured from the ponds of Rybarstvi Nove Hrady Ltd. and then transferred to the FFPW.

In total, 1500 intensively reared (group IRJ) juveniles (TL=133.3±7.2 mm; W=23.8±3.2 g) and 1500 pond-reared (group C) juveniles (TL=122.4±6.6 mm; W=21.1±2.8 g) were used in this study. Fish were marked with a ventral fin clip (group C left fin, group IRJ right fin) and separated into three batches, each comprising 500 pond-reared juveniles and 500 intensively reared juveniles. Batches were stocked into separate 400-m^2 earth ponds (three ponds, 1000 fish in each pond) for 178-day culture, from 19th October until 5th May. To support the fish during the pond rearing and provide them some supplemental nutrition, prey fish *Pseudorasbora parva* (TL 15-46 mm) in total biomass of 50 kg was added to each experimental pond. *Pseudorasbora parva* is not a native fish species but it forms naturalized populations in the Czech Republic (Lusk *et al*., 2011) and it is commonly used as prey fish in Czech pond fishery. Water temperature in ponds was measured continually using a data logger (Minikin T, Czech Republic). Average WT was 2.5±1.6 °C during the trial. Ponds were drained on 5 May and fish of both groups (C and IRJ) were identified and counted for calculation of the survival rate. A sample of 35 fish from each group and pond was measured and weighed to assess the total length and average weight, respectively. Specific growth rate (SGR) and Fulton coefficient (FC) were calculated according to Policar *et al*. (2011a; 2011b) at the harvesting day.

Re-adaptation to RAS Conditions

Intensively cultured fish (W= 24.6±8.1 g; TL= 151.7±13.3 mm) from all three ponds were separated into six groups of 70 fish and transferred to six 180-l circular tanks of a RAS in FFPW. A warm-up period from ambient pond temperature took three days (continual increasing of WT). Juveniles were treated with NaCl bath (3 kg.m^{-3}, duration of bath 30 minutes) at the first day of warm-up period.

After the warm-up period, fish were not fed for 24 hours, but they were subsequently fed *ad-libitum* for 48 hours with a 1:1 mixture of frozen bloodworm larvae (*Chironomus* sp.) and artificial pellet feed (BioMar, INICIO plus 2 mm). From the following day, all fish were fed only the commercial pelleted feed at 1% of fish biomass (Zakes *et al*., 2004), adjusted every seventh day according to the current biomass of each experimental tank.

Belt feeders were used for continual feeding during the light period of a 12L : 12D light regime and illumination intensity of 40 lux at the water surface. Fish were reared under RAS conditions for 46 days. WT and OS were measured twice daily with an oximeter (OxyGuard). Average WT was 22.8±1.4°C and OS = 109±7%.

At the end of the rearing period, fish were counted for determination of survival rate, measured and weighed for calculation of SGR, FC (Policar *et al*., 2011a; 2011b) and FCR (Fiogbe and Kestemont, 2003).

The program Statistic 10, one way Anova analys with Tuckey *post-hoc* test were used for comparison of the survival rate, SGR and FC of group IRJ with group C after the pond culture. The level of significance was set at P<0.05.

Results

Adaptation and Culture under Pond Conditions

Survival rate of intensively cultured fish was significantly higher than that of group C. However, there were observed no significant differences in SGR and FC between group IRJ and group C (Table 1). More than 90% of the prey fish (91-100%) had been consumed in all ponds at the end of pond culture.

Re-adaptation and Following Culture of Intensively Cultured Fish in RAS

No IRJ fish died during the 3-day adaptation period after re-transfer to the RAS. The intensively cultured fish harvested from ponds were re-adapted without any complications. Survival of IRJ fish during the 46-day intensive culture was 98.4±0.9%

Table 1. Survival, specific growth rate (SGR) and Fulton's coefficient (FC) assessed after 178-day pond culture. Different letters indicate significant difference (P<0.05).

Experimental Groups	Survival [%]	SGR [%.d^{-1}]	FC
IRJ group	65.2±15.9^a	0.018±0.012^a	1.02±0.13^a
Group C	47.3±1.6^b	0.014±0.027^a	0.95±0.57^a

and SGR was at 0.732±0.441%.d^{-1}. FC of IRJ fish was 1.20±0.09 and FCR of fed feed was 2.1±1.2.

Discussion

The primary aim of intensive aquaculture is to produce high-quality marketable fish throughout the year. Out-of-season spawning can lead to production of several batches of larvae and fry ensuring stable year-round production of marketable fish (Zakes and Szczepkowski, 2004). With the system assessed in this study, based on a combination of pond and RAS culture, production can be staggered over the course of the year with relatively low additional effort and production cost.

One of the most important results of our study was no complications and non-problematic adaptation of intensively cultured juveniles to pond conditions. The survival rate of group IRJ was higher (65.2 ± 15.9%) than that of control fish (47.3 ± 1.6%) during the pond culture phase. Rennert *et al*. (2005) carried out a similar experiment where they also compared the survival of juvenile pikeperch after wintering. They compared a group of pikeperch juveniles (31.6 g) that had been fed pellet feed with a group of fish (13.8 g) which had been fed only live food. These groups were stocked into ponds in the fall and were harvested in the spring after a winter period of 176 days. Survival after wintering was the same in both groups at 83.3%. Survival was higher than groups in our study, but Rennert *et al*. (2005) used a much lower fish density. They stocked only 24 fish (12 fish from each group) into ponds with average area of 667 m^2 compared to 1000 fish per 400 m^2 of pond area in our study. This different fish density in both studies could affect the survival rate.

According to presented results and those of Rennert *et al*. (2005), intensively reared pikeperch juveniles can be stocked in open waters instead of one-summer-old pond-produced pikeperch juveniles. Production of pikeperch juveniles in intensive aquaculture is more stable and effective method compared to pond culture which suffers from annual fluctuations of production (Policar *et al*., 2014).

The second most important outcome of presented study was the ease of which the intensively reared fish converted from natural feed to an artificial diet after pond culture. This demonstrated that methods of year-round production of pikeperch might not only be limited to out-of-season spawning which is currently the most common practice for year-round production of pikeperch fry, juveniles and subsequently, marketable fish. Combination of pond and RAS culture can also be employed to produce several size categories of pikeperch with the same age within one natural production cycle, which is easier to be manage and cheaper than out-of-season spawning techniques. Pikeperch growth under pond culture is slower than RAS (WT in ponds is usually lower than in RAS and fish growth rate is highly affected by WT), therefore, fish of the same age can be available in several different size. One disadvantage of this rearing technique could be the potential for transferring parasites from the ponds to the RAS system. If the farmers follow the basic rules of hygiene, quarantine or antiparasitic treatments, the problems with parasites occurrence should not appear (Policar *et al*., 2014). This type of controlled-combined pikeperch culture can be suitable especially for fish production in countries with pronounced winter season and large areas of production ponds such as: the Czech Republic, Hungary, Germany, etc.

To conclude this study, we can say that presented kind of pikeperch culture could be used as an alternative to out-of-season spawning to produce several size categories within natural production cycle and help the farmers to supply the market with marketable fish all year round. High winter survival of intensively cultured fish is also promising for restocking of pikeperch juveniles to fishing grounds.

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